

TETRA TECH, INC.

December 6, 2006

TO: Dan Cain, Salton Sea Authority; Chris Holdren and Paul Weghorst, Bureau of Reclamation

FROM: Roberto Pinon and Sujoy Roy, Tetra Tech, Inc.

RE: Pilot Testing of Water at the Salton Sea, California

1 INTRODUCTION

The purpose of this technical memorandum is to summarize the results of chemical analysis of water samples collected during a pilot test conducted at the Salton Sea from October 12 through November 15, 2006 and preliminary conclusions. Tetra Tech is waiting for the results of analysis of absolute biological oxygen demand (BOD₂₀) samples submitted for chemical analysis on November 14 and 15. This memo is a summary of data obtained to date and will be followed by more detailed evaluation of results in the final report. This memo is being submitted for discussion purposes and to proceed with system decommissioning. Attached to this memo is a spreadsheet containing all data that have been collected as part of the pilot test.

The pilot unit consisted of a HiPOx advanced oxidation and filtration system designed to process hypolimnetic water from the Salton Sea. Water samples were collected to assess the hydrogen sulfide removal efficiency of the advanced oxidation system and to evaluate other aesthetic components of the water. Most samples were artificially spiked with sodium sulfide to create artificially elevated sulfide concentrations of up to 25 milligrams per liter (mg/L). Elevated sulfide concentrations in water in this range have been observed during the hot summer months typically June through September when the Sea is stratified. Sulfide is produced as a result of oxygen demand in the sediments and

hypolimnetic waters and low oxygen transfer from upper layers. Sulfide concentrations decrease when the lake destratifies and the water column is oxygenated. Because of the wind-driven mixing in the Sea, sulfide concentrations are highly variable even during the summer months.

2 SAMPLE COLLECTION BY ERS

Collection of hypolimnetic water (sampling) was conducted at the location indicated on Table 1.

Table 1 – Sampling Location		
Location	North	West
ERS Station	33° 25.433	115° 50.245

- *Sample Collection* – Samples of hypolimnetic water were collected with a gasoline powered pump. The pipe was lowered to a depth of 35 feet below the surface, and the water was pumped into one pillow tank container. The 700-gallon pillow tank was transported by barge to the ERS station for sample processing. Sample processing was performed with a pilot unit supplied by APT Water. The pillow tank and pump were equipped with a camlock release system to quickly connect and disconnect the pump to the system. Sample monitoring was conducted using a portable oxidation-reduction potential (ORP) meter (i.e., a YSI Probe 6600 or Horiba U22 capable of recording turbidity, salinity and pH)
- *Water Transfer* – Once the pillow tank was filled with water, the pillow tank was transported to the ERS station. A transfer hose was used to pump water from the pillow tank to the Baker tank. The hose consisted of a 2-inch flexible pipe supported by the crane such that the barge could approach the shore at a safe distance. Depending on the weather conditions it took five to six hours to fill the baker tank with approximately 2,800 gallons of water.

During the operation of the pilot plant, the dissolved oxygen (DO) concentrations varied substantially. Elevated DO concentrations in water do not maintain dissolved sulfide as a result of aerobic conditions in the hypolimnetic area. To model the performance of advanced oxidation system, the samples were spiked with one or two pounds of flaked sodium sulfide.

3 PILOT PLANT OPERATION

The pilot plant consisted of the following:

- One 4,500-gallon feed tank

- One feed pump operating with a variable frequency drive (VFD)
- One 10 gallon per minute (gpm) multimedia filter
- One skid mounted advanced oxidation system
- One 700-gallon holding tank
- One 10-micron bag filtration unit for multimedia filter backwash water
- One 30 kilovolt-ampere (kVa) generator to power the feed pump and the advanced oxidation system

The VFD feed pump was used to pump water from the Baker tank to the sand filter and into the HiPOx system. After processing, the water was transferred into a holding tank prior to discharge into the Salton Sea. The water in the holding tank was designed to supply the VFD pump with backwash water for the multimedia filter or to prevent a discharge of water during startup and low ozone concentrations.

Backwash water was filtered with a 10 micron bag filter unit prior to discharge into the Salton Sea. The first two days of testing were conducted with clean water.

During clean water tests, the Baker tank was filled with the clean water. The operation flow of the system was set at 10 gpm to test for adequate operation of the filters, oxidation systems, and system control.

3.1 Operations Schedule

Table 2 summarizes the operation schedule from October 13 through November 15, 2006.

Table 2 – Operations Program		
Location	Operation	Operators
Friday, October 13, 2006	Equipment Receiving (HiPOx)	Roberto Piñón Norman Ng
Monday, October 16, 2006	Mechanical and Electrical Installation	Roberto Piñón Norman Ng
Tuesday, October 17, 2006	Mechanical and Electrical Installation Clean Water Tests No samples collected and System Troubleshooting and Training	Roberto Piñón Norman Ng
Wednesday, October 18, 2006	Mechanical and Electrical Installation Finalized	Norman Ng
Thursday, October 19, 2006	Tests with Clean Water Influent and effluent samples collected and analyzed with the portable Hach colorimetric test	Norman Ng Shawn Ferron Roberto Piñón
Friday, October 20, 2006	Tests with Clean Water Influent and effluent samples collected	Shawn Ferron Norman Ng

Table 2 – Operations Program		
Location	Operation	Operators
Monday, October 23, 2006	Tests with Sampled Water Influent and effluent samples collected not-spiked with Na ₂ S	Roberto Piñón Norman Ng
Tuesday, October 24, 2006	Tests with Sampled Water Influent and effluent samples collected Spiked Samples with Na ₂ S Technician Training	Roberto Piñón Norman Ng Tony Hernandez
Wednesday, October 25, 2006	Tests with Sampled Water Influent and effluent samples collected Spiked Samples with Na ₂ S Technician Training	Roberto Piñón Norman Ng Tony Hernandez
Thursday, October 26, 2006	Tests with Sampled Water Influent and effluent samples collected Spiked Samples with Na ₂ S Technician Training	Roberto Piñón Norman Ng Tony Hernandez
Friday, October 27, 2006	Tests with Sampled Water Influent and effluent samples collected Spiked Samples with Na ₂ S	Roberto Piñón Tony Hernandez
Monday, October 30, 2006	Tests with Sampled Water Influent and effluent samples collected Spiked Samples with Na ₂ S	Roberto Piñón Norman Ng Lisa Bercik
Tuesday, October 31, 2006	Tests with Sampled Water Influent and effluent samples collected Spiked Samples with Na ₂ S	Roberto Piñón Norman Ng Lisa Bercik
Wednesday, November 1, 2006	Tests with Sampled Water Influent and effluent samples collected Spiked Samples with Na ₂ S	Norman Ng Lisa Bercik
Thursday, November 2, 2006	Tests with Sampled Water Influent and effluent samples collected Spiked Samples with Na ₂ S	Tony Hernandez Lisa Bercik
Friday, November 3, 2006	Tests with Sampled Water Influent and effluent samples collected Spiked Samples with Na ₂ S	Tony Hernandez Norman Ng
Monday, November 6, 2006	Tests with Sampled Water Influent and effluent samples collected Operation with ozone and spiked samples	Tony Hernandez Lisa Bercik
Tuesday, November 7, 2006	Tests with Sampled Water Influent and effluent samples collected Operation with ozone and spiked samples	Lisa Bercik Norman Ng
Wednesday, November 8, 2006	Tests with Sampled Water Influent and effluent samples collected Operation with Ozone and spiked samples	Lisa Bercik Norman Ng
Thursday, November 9, 2006	Tests with Sampled Water Influent and effluent samples collected Operation with ozone and spiked samples	Lisa Bercik Tony Hernandez
Friday, November 10, 2006	Tests with Sampled Water Influent and effluent samples collected Operation with ozone and spiked samples	Lisa Bercik Tony Hernandez

Table 2 – Operations Program		
Location	Operation	Operators
Monday, November 13, 2006	Tests with Sampled Water Influent and effluent samples collected Operation with ozone and spiked samples	Lisa Bercik Roberto Piñón
Tuesday, November 14, 2006	Tests with Sampled Water Influent and effluent samples collected Operation with ozone/peroxide and spiked samples	Lisa Bercik Tony Hernandez
Wednesday, November 15, 2006	Tests with Sampled Water Influent and effluent samples collected Operation with ozone/peroxide and spiked samples	Lisa Bercik Roberto Piñón
To be scheduled	System Decommissioning	Norman Ng Roberto Piñón

4 SAMPLE COLLECTION AND SAMPLE TRANSPORTATION TO CALSCIENCE

After ERS collected one sample batch consisting of four loads, each load with 700 gallons of water, the water was spiked with sodium sulfide. To spike the samples with sodium sulfide, the compound was pre-dissolved in water and added to the baker tank. Sulfide spiking was conducted prior to transferring the last load of sample from the pilot tank into the baker tank for mixing.

Water processing began after the water in the baker tank was spiked and the system was allowed to operate for one hour. During that time, all sample bottles and chains of custody were prepared. Once the hour of operation was completed the systems influent and effluent were sampled at varying ozone or ozone/peroxide concentrations.

The selection of ozone dosage was determined with two colorimetric tests:

- Hach Dissolved Sulfide Colorimetric Test
- Hach Ozone Colorimetric Test

The Hach ozone colorimetric test was used during the third week of operation to identify the residual ozone concentration required to remove all dissolved sulfide and total sulfide.

On Mondays, Wednesdays, and Fridays the samples were transported to Calscience in Garden Grove, California and delivered under chain of custody. The samples were analyzed for the following parameters in accordance with the corresponding chain of custody:

- Total Suspended Solids (TSS)
- Total Organic Carbon (TOC)
- Chemical Oxygen Demand (COD)
- Chemical Oxygen Demand, Filtered (COD_f)
- Ammonia (NH₃-N)
- Dissolved Sulfide
- Total Sulfide
- Nitrites
- Nitrates
- Total Kjeldahl Nitrogen (TKN)
- Selenium
- Total Phosphorus
- Absolute Biological Oxygen Demand (BOD₂₀)
- Absolute Nitrogenous Biological Oxygen Demand (NBOD₂₀)

On Tuesdays and Thursdays the water samples were analyzed for total sulfide and COD by the Department of Environmental Sciences at the University of California at Riverside (UCR).

All samples delivered to UCR were cooled immediately after collection and preserved in accordance within laboratory specifications.

The UCR laboratory was selected for analysis of selected dissolved sulfide and COD samples due to its experience with sulfide and COD analyses in the matrix of the Salton Sea and the need to conduct dissolved sulfide analysis with a fast turnaround. COD analysis of samples was conducted in the UCR lab due the high concentrations of inorganic with high COD values (>1000 mg/L) per standard operating procedures. The UCR laboratory created an analytical procedure¹ for the analysis of COD samples at the Salton Sea.

All field results were recorded, including hydrogen sulfide concentrations at the influent and effluent, ozone/peroxide dose used, and system flow. The operating parameters are summarized in Table 5.

5 WATER SAMPLE DATA TRENDS

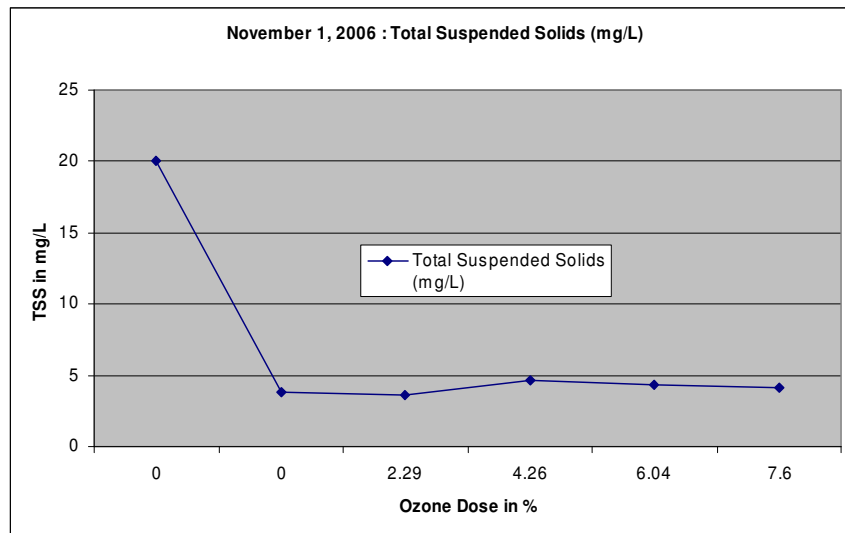
The charts included in Attachment A summarize the results of analysis of samples obtained during the pilot test.

¹ UCR has developed the COD analysis method as follows: A standard curve is made using artificial Salton Sea water and known amounts of COD. The COD analysis is a closed vial, chromate digestion with spectrophotometric measurement of Cr(VI) to Cr(III) reduction. The vials are obtained pre-filled from CHEMetrics, Inc, and the low range tubes because a large dilution is made to eliminate the chloride interference. Even with the dilution, interference is not completely eliminated, and the matrix-matched standards are used for comparison.

The following results were observed for TSS data:

- TSS was significantly reduced by the sand filtration system in the majority of water samples.
- There was no clear increase or decrease in TSS as a result of ozone or ozone/peroxide doses within the advanced oxidation system.
- The only exception to this occurred in the initial days of operation when the difference in TSS results may have been attributed to insufficient processing time and mixing of water within the system. The problem was resolved by allowing the contents of the baker tank to empty prior to complete shutdown of the system.

The November 1, 2006 chart is considered to be representative of the pilot testing results:



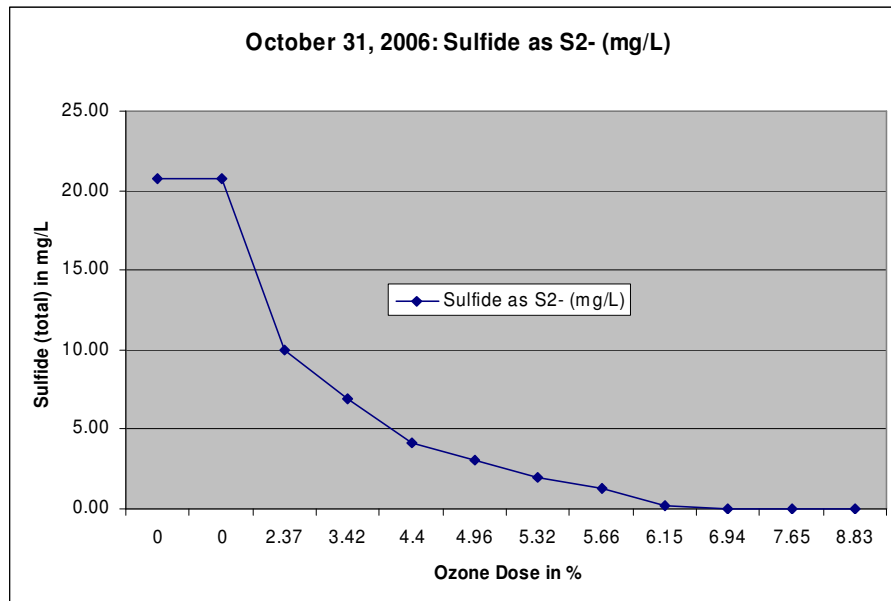
Notes: The first two values at 0% ozone are for raw water and filtered water. During the pilot testing, results at 1% ozone dose are equivalent to 10 mg/L of ozone.

The following trends were observed for total sulfide and dissolved sulfide data:

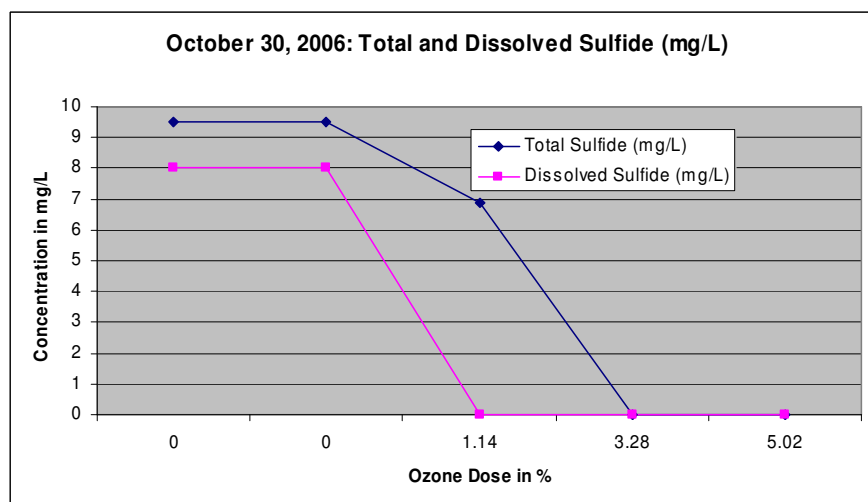
- Concentrations of both total sulfide and dissolved sulfide generally were not significantly affected by filtration.
- The most substantial reduction in sulfides occurred at low ozone doses.
- Dissolved sulfide was oxidized at a low ozone dose, and total removal of dissolved sulfide and total sulfide was generally observed at residual ozone concentrations of 0.5 mg/L in the effluent.

- The residual ozone concentrations were estimated based on the ozone test kit obtained from Hach.
- Two days of operation required a higher percentage of ozone for the sulfide concentrations to be eliminated. This problem may have been caused by an ozone leak that was detected and fixed.

The following dissolved sulfide and total sulfide charts are considered to be representative of the system performance.



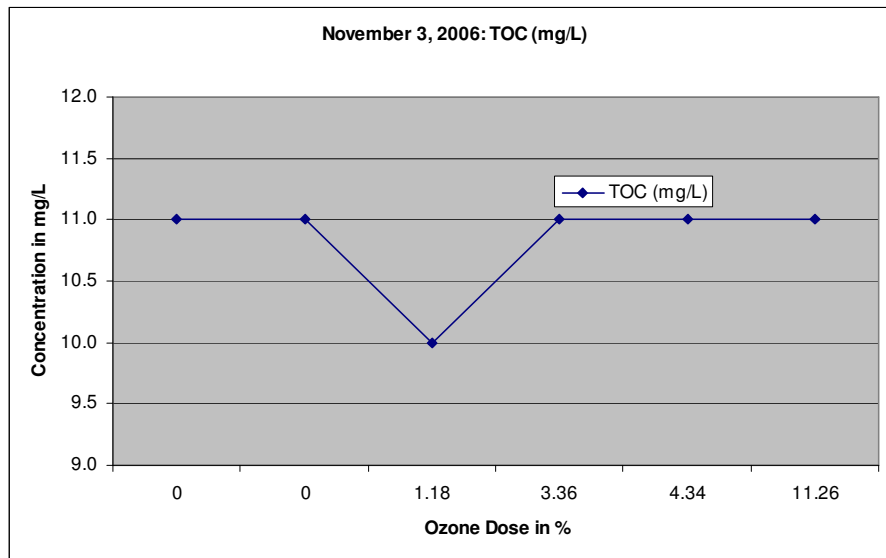
Notes: The first two values at 0% ozone are for raw water and filtered water. During the pilot testing, results at 1% ozone dose are equivalent to 10 mg/L of ozone.



Notes: The first two values at 0% ozone are for raw water and filtered water. During the pilot testing, results at 1% ozone dose are equivalent to 10 mg/L of ozone.

The following trends were observed for TOC data:

- Sand filtration did not consistently reduce the TOC in samples. A decrease was recorded in November 6 and November 8.
- The TOC data does not show a consistent reduction of TOC at increasing ozone concentrations.

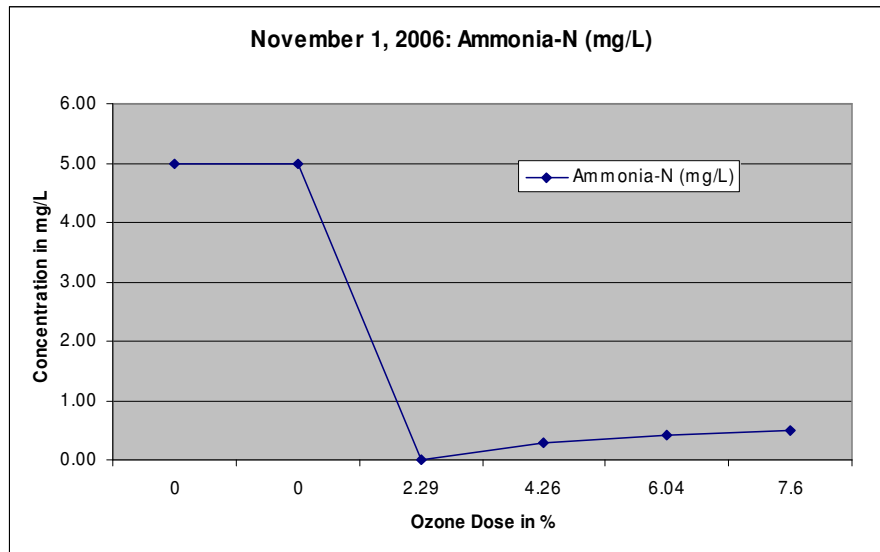


Notes: The first two values at 0% ozone are for raw water and filtered water. During the pilot testing, results at 1% ozone dose are equivalent to 10 mg/L of ozone.

The following trends were observed for ammonia data:

- There were six days in which little or no ammonia was detected in the water samples before the water entered the treatment system.
- The change in ammonia concentrations was not consistent over the six days.
- The ammonia concentrations either remained at zero, spiked and then returned to zero, or increased as a higher percentage of ozone was used.
- The variation in ammonia results is expected to result from one or several of the following: 1) Ammonia concentrations were close to the method detection limit, 2) Some ammonia may have been oxidized into nitrites or nitrates, and 3) An increase in nitrites or nitrates was not detected suggesting that ammonia may have been lost at the oxygen-ozone/water separation unit.

- Of the three days when ammonia was detected in the water samples before entering the water treatment system, the concentrations of ammonia were reduced to zero during the advanced oxidation portion of the water treatment system.
- The sand filter was observed to have no impact on ammonia concentrations.

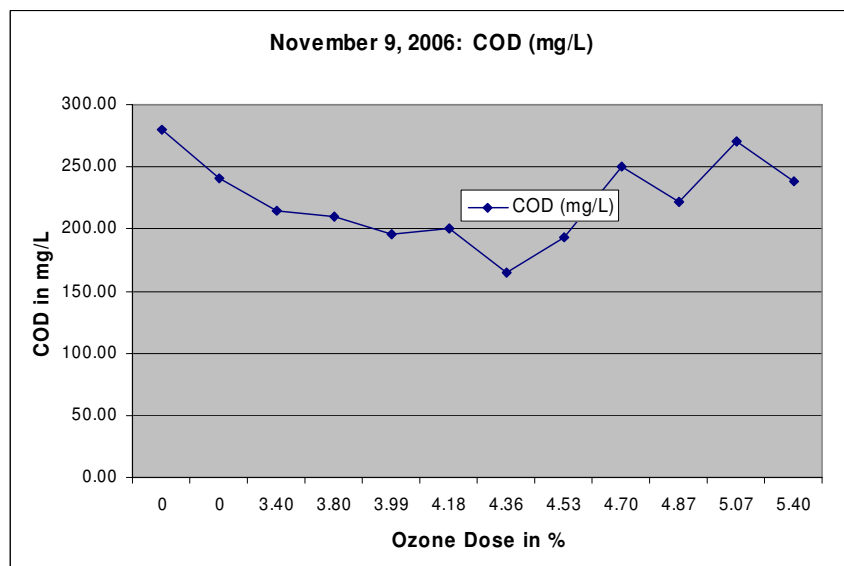
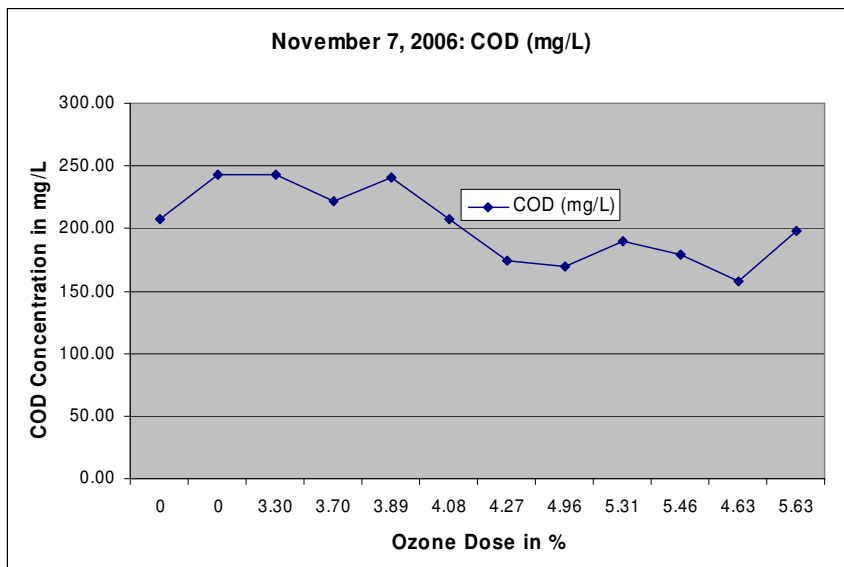


Notes: The first two values at 0% ozone are for raw water and filtered water. During the pilot testing, results at 1% ozone dose are equivalent to 10 mg/L of ozone.

The following trends were observed for COD data:

- The majority of water samples showed a decrease in COD concentrations after filtration.
- There was no clear trend in the reduction of COD concentrations as a result of ozone or ozone/peroxide addition.
- The inconsistent trends may have resulted from the difficulty of evaluating COD with standard methods and as a result of a high concentration of inorganic compounds in samples.
- The method used by CalScience was expected to show higher COD values associated with the oxidation of inorganic compounds, and the COD values provided by CalScience did not provide a consistent downward trend.
- The UCR spectrophotometry method of analysis developed for chemical analysis of samples from the Salton Sea did not provide consistent downward trends with higher ozone or ozone peroxide doses.

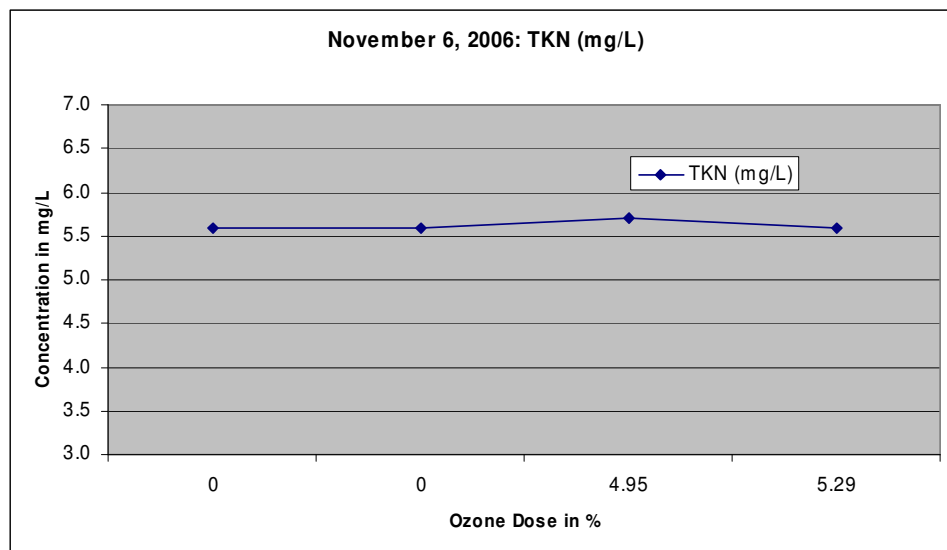
- To evaluate the biodegradable fraction of COD, samples of processed water were submitted to CalScience for BOD₂₀ and NBOD₂₀ analysis. The results of analysis are still pending.



Notes: The first two values at 0% ozone are for raw water and filtered water. During the pilot testing, results at 1% ozone dose are equivalent to 10 mg/L of ozone.

The following trends were observed for TKN data:

- Although there were small fluctuations in concentrations of TKN at increasing ozone doses, TKN did not appear to be significantly affected by either the sand filter or the advanced oxidation system.

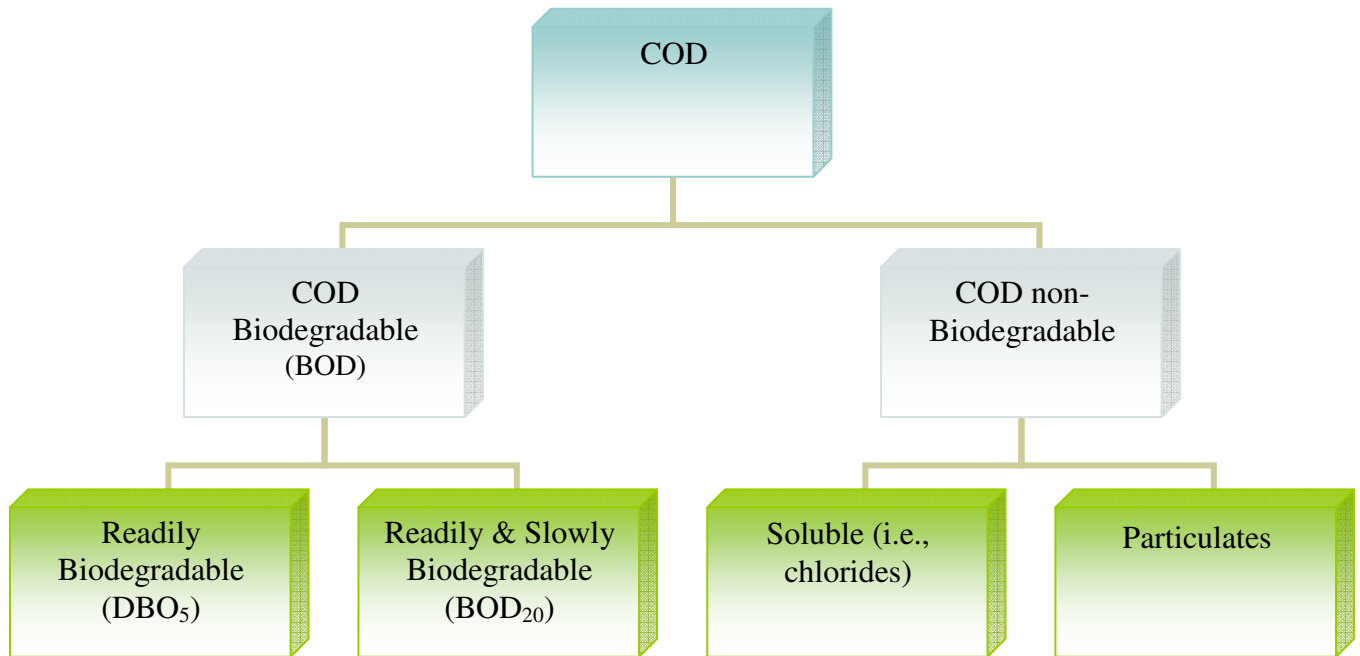


6 SUMMARY OF RESULTS AND DISCUSSION

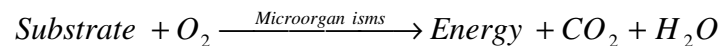
Based on the results of analysis of samples collected during the pilot testing the following was observed:

- The most significant reduction in TSS, TOC, and COD was achieved by the multimedia filter.
- The oxidation of dissolved sulfide and total sulfide was demonstrated with the addition of ozone and ozone/peroxide.
- The results indicate that approximately three mg/l of ozone are required to oxidize one mg/L of total sulfide. The ozone demand is expected to be associated with the ozone required to oxidize total sulfide and other compounds in the Salton Sea water that can be oxidized by ozone.
- A reduction of COD was not consistently observed at increased ozone dosages in samples analyzed by Calscience and UCR. This may have resulted from the interference inorganic compounds in the matrix of the Salton Sea samples or the required dilution which may have increased the error.
- Ozone has an electrochemical oxidation potential (EOP) of 2.08 volts (V) and ozone peroxide (hydroxyl radical) has an EOP of 2.8 V. Both compounds have an EOP higher than chlorine which has an EOP of 1.36 V.

The detectable concentrations of COD in unprocessed and processed water samples originate from two sources: 1) biodegradable material that can be quantitatively evaluated as BOD (substrate), and; 2) non-biodegradable material associated with inorganic and organic compounds that cannot be used by micro-organisms as a substrate.



The substrate availability in hypolimnetic water would consume oxygen through the following reaction:



Once all oxygen in the hypolimnetic water is consumed, the anoxic and anaerobic reactions will use electron receptors (i.e., nitrates, nitrites, sulfates) to oxidize the substrate. The anoxic processes are suspected to be responsible for the production of hydrogen sulfide.

To determine if the processed water contains available substrate, BOD samples were collected on November 14 and 15, 2006 and submitted to Calscience for BOD₂₀ and NBOD₂₀ analysis. The results are expected to report the amount of substrate available after ozone and ozone/peroxide addition. Ozone and ozone peroxide are expected to significantly reduce BOD in samples since these oxidizing agents are stronger than chlorine.

The sand filter was backwashed once on November 14, 2006 after processing approximately 35,700 gallons of Salton Sea water. The sand filter was designed for a flow of 10 gallons per minute. During the multimedia filter backwash operation, it was

determined that filtration alone will not offer sufficient treatment to process backwash wastewater water. A chemical treatment (i.e., flocculation or coagulation with filtration) may be required to treat backwash wastewater.

No substantial foaming was observed in the reactor and some mild foaming was observed in the final effluent tank. Foaming did not interfere with the operation of the pilot plant.

7 OPERATIONS LOG

Table 3 summarizes the general water chemistry parameters recorded by ERS with a Horiba 22 probe during water collection.

Table 3 – Hypolimnetic Water Collection Results									
Location	pH	EC mS/cm	Turbidity NTU	DO mg/L	Temp. °C	Depth m	Salinity ‰	TDS g/L	ORP mV
10/23	8.14	6.02	0	0.16	23.5	10	4	36	-186
10/23	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/23	8.18	6.05	0	0.12	23.5	10	4	36	-262
10/23	8.18	6.06	0	0.11	23.5	10	4	36	-270
10/24	8.18	6.06	0	0.11	23.5	10	4	36	-270
10/24	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/24	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/24	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/25	8.23	6.18	0	1.01	23.5	8	4	37	-199
10/25	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/25	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/25	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/26	8.23	6.21	0	1.01	23.5	10	4	37	173
10/26	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/26	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/26	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/27	8.22	6.23	0	0.68	22.9	10	4	38	181
10/27	NR	NR	NR	NR	NR	NR	NR	NR	NR

Table 3 – Hypolimnetic Water Collection Results									
Location	pH	EC mS/cm	Turbidity NTU	DO mg/L	Temp. °C	Depth m	Salinity ‰	TDS g/L	ORP mV
10/27	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/27	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/30	8.27	6.3	0	-	22.9	10	4	38	177
10/30	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/30	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/30	NR	NR	NR	NR	NR	NR	NR	NR	NR
10/31	8.32	6.37	0	3.62	22.9	10	4	38	161
11/01	8.29	6.37	0.0	2.49	22.8	10	4.0	38	203
11/02	8.33	6.37	0.0	2.36	22.6	10	4.0	37	-188
11/03	8.23	6.37	0.0	1.43	22.5	10	4.0	38	-174
11/06	8.25	6.16	0	2.11	22.4	10	4.0	39	186
11/06	8.26	6.18	0	1.76	22.4	10	4.0	39	186
11/06	8.25	6.16	0	1.13	22.44	10	4.0	39	188
11/06	Only 3 loads were processed on 11/06								
11/07	8.32	6.40	0	2.63	22.4	10	4	39	158
11/07	8.18	6.54	0	2.16	22.32	10	4	39	186
11/07	8.27	6.45	0	1.92	22.39	10	4	39	183
11/07	Only 3 loads were processed on 11/07								
11/08	8.24	6.15	0	1.76	22.42	10	4	37	166
11/08	8.26	6.21	0	1.68	22.44	10	4	37	166
11/08	8.26	6.22	0	1.54	22.44	10	4	38	166
11/08	8.25	6.22	0	1.33	22.46	10	4	37	167
11/09	8.24	6.28	0	2.49	22.40	10	4	39	147
11/09	8.30	6.23	0	2.08	22.42	10	4	39	145
11/09	8.30	6.21	0	1.64	22.40	10	4	39	145
11/09	8.30	6.23	0	1.55	22.40	10	4	39	145
11/10	8.27	6.34	0	0.55	22.42	10	4	38	186

Table 3 – Hypolimnetic Water Collection Results									
Location	pH	EC mS/cm	Turbidity NTU	DO mg/L	Temp. °C	Depth m	Salinity ‰	TDS g/L	ORP mV
11/10	8.26	6.34	0	0.52	22.42	10	4	38	178
11/10	8.27	6.34	0	0.44	22.44	10	4	39	177
11/10	8.27	6.34	0	0.46	22.44	10	4	39	188
11/13	8.40	6.24	0	6.00	21.31	10	4.0	38	204
11/13	8.39	6.24	0	5.84	21.33	10	4.0	38	200
11/13	8.40	6.25	0	5.80	21.33	10	4.0	37	198
11/13	8.37	6.31	0	5.84	21.29	10	4.0	38	189
11/14	8.44	6.37	0	6.80	21.1	10	4.0	38	188
11/14	8.38	6.36	0	6.37	21.1	10	4.0	38	188
11/14	8.36	6.36	0	6.50	21.2	10	4.0	38	189
11/14	8.36	6.36	0	6.06	21.2	10	4.0	38	188
11/15	8.40	6.26	0	5.44	21.2	10	4.0	38	173
11/15	8.41	6.25	0	5.40	21.2	10	4.0	38	173
11/15	8.40	6.25	0	5.36	21.2	10	4.0	38	170
11/15	8.40	6.25	0	5.14	21.3	10	4.0	38	173

Notes: NR – Not Recorded
EC – Electrical conductivity
mS/cm – millisiemens per centimeter
NTU – Nephelometric turbidity units
mV – millivolts

Table 4 summarizes the data collected during sample processing.

Table 4 – Sample Login Table														
Run	Date	Time	Flow Rate gpm	O ₂ Flow slm	O ₃ Conc. Wt%	O ₃ Gen Power %	O ₃ Gen Power %	Reactor Inlet Pressure (Pi) psi	Reactor Outlet Pressure (Po) psi	Sand Filter Pressure (Ps) psi	Effluent H ₂ S Conc. mg/L	Residual O _{3m} mg/L	H ₂ O ₂ Conc. %	Notes
1	10/23	15:00	10	28	2.23	10		25	8	0	NS	NS	-	TW23-2.23
2	10/23	15:00	10	28	3.33	15		25	8	0	NS	NS	-	TW23-3.33
3	10/24	12:00	10	28.5	3.33	15		20	8	0	2.0	NS	-	TW24-3.33
4	10/24	12:15	10	28.5	4.25	20		20	8	0	0.75	NS	-	TW24-4.25
5	10/24	12:30	10.2	28.5	8.39	50		20	9	0	8.37	NS	-	TW24-8.39
6	10/24	11:43	9.8	28.5	2.08	10		20	8	0	More than 2.0	NS	-	TW24-2.08
7	10/25	11:55	9.5	28.5	4.23	20		20	9	0	H2S Odor	NS	-	TW25-4.23
8	10/25	12:10	9.7	28.5	5.99	30		20	8	0	0.5	Ozone smell	-	TW25-5.99
9	10/25	12:55	9.8	28.5	3.21	15		20	8	0	1.15	NS	-	TW25-3.21
10	10/26	13:01	9.7	28.5	0.87	5		20	8	1	0.5	NS	-	TW26-0.87
11	10/26	13:05	9.8	28.5	1.98	10		20	8	1	H2S Odor	NS	-	TW26-1.98
12	10/26	13:12	9.8	28.5	3.00	15		20	8	1	H2S Odor	NS	-	TW26-3.00
13	10/26	13:21	9.7	28.5	3.93	20		21	8.5	1.5	H2S Odor	NS	-	TW26-3.93
14	10/26	13:29	9.8	28.5	4.94	25		21	8	1.5	No Smell / 23,25	NS	-	TW26-4.94
15	10/26	13:36	9.8	28.5	5.8	30		21	8	1.5	H2S Odor	NS	-	TW26-5.8

Table 4 – Sample Login Table														
Run	Date	Time	Flow Rate gpm	O ₂ Flow slm	O ₃ Conc. Wt%	O ₃ Gen Power %	O ₃ Gen Power %	Reactor Inlet Pressure (Pi) psi	Reactor Outlet Pressure (Po) psi	Sand Filter Pressure (Ps) psi	Effluent H ₂ S Conc. mg/L	Residual O _{3 m} mg/L	H ₂ O ₂ Conc. %	Notes
16	10/26	13:45	9.7	28.5	6.75	35		20	7.5	1.5	No Smell	NS	-	TW26-6.75
17	10/26	13:54	9.8	28.5	7.49	40		20	8	1.5	No smell	NS	-	TW26-7.49
18	10/26	14:05	9.7	28.5	6.28	32		20	8	1.5	No smell	NS	-	TW26-6.28
19	10/26	14:12	9.7	28.5	1.98	9		21	8	1.5	H2S Odor	NS	-	TW26-1.98
20	10/26	14:19	9.7	28.5	1.75	8		21	8	1.5	H2S Odor	NS	-	TW26-1.75
21	10/27	13:00	9.7	28.5	8.78	50		21	7	2.5	No H2S Smell	NS	-	TW26-8.78
22	10/27	13:17	9.8	28.5	7.47	40		20	8	2.5	H2S Odor	NS	-	TW27-7.47
23	10/27	13:36	9.8	28.5	5.98	30		20	7	2.5	H2S Odor	NS	-	TW27-5.98
24	10/27	13:53	9.8	28.5	4.27	22.7	21.7	21	7	3	H2S=1.5 mg/L	NS	-	TW27-4.27
25	10/27	14:20	9.8	28.5	3.34	17.6	17.4	21	7	2.5	H2S Odor	NS	-	TW27-3.34
26	10/30	12:05	28.8	26.2	5.02	26.2	26.2	21	9	2.0	No H2S Smell	NS	-	TW30-5.02
27	10/30	12:25	28.6	17.4	3.28	17.5	17.4	22	9	2.0	Slight H2S Smell	NS	-	TW30-3.28
28	10/30	12:55	28.7	9.8	1.14	10.0	9.8	22	9	2.5	H2S smell Hach=1.15 mg/L	NS	-	TW30-1.14
29	10/31	10:45	9.8	28.6	9.93	51.1	50.7	21	9	2	No odor		-	> 2.25 mg/L hach on raw waer
30	10/31	10:50	9.8	28.6	7.65	41.4	41.0	21	8.5	2	No odor		-	
31	10/31	10:57	9.8	28.6	6.94	36.6	36.1	21	8.5	0	Slight H2S odor		-	

Table 4 – Sample Login Table														
Run	Date	Time	Flow Rate gpm	O ₂ Flow slm	O ₃ Conc. Wt%	O ₃ Gen Power %	O ₃ Gen Power %	Reactor Inlet Pressure (Pi) psi	Reactor Outlet Pressure (Po) psi	Sand Filter Pressure (Ps) psi	Effluent H ₂ S Conc. mg/L	Residual O _{3 m} mg/L	H ₂ O ₂ Conc. %	Notes
32	10/31	11:00	9.7	28.7	6.15	31.6	31.2	21	9	2	Slight H ₂ S odor		-	<0.25 mg/L hach
33	10/31	11:07	9.8	28.6	5.66	28.7	28.3	21	9	1	Slight H ₂ S odor		-	
34	10/31	11:14	9.7	28.5	5.32	26.8	26.4	21	9	0	H ₂ S Odor		-	<0.25 mg/L hach
35	10/31	11:20	9.8	28.6	4.96	24.8	24.5	21	9	2	H ₂ S Odor		-	0.5 mg/L hach
36	10/31	11:25	9.7	28.7	4.40	21.9	21.6	21	9	2	H ₂ S Odor		-	
37	10/31	11:33	9.7	28.7	3.42	17.5	17.4	21	9	2	H ₂ S Odor		-	
38	10/31	11:38	9.6	28.7	2.37	13.7	13.6	21	9	2	H ₂ S Odor		-	
39	11/1	10:15	9.8	28.5	7.60	41.4	41.0	22	9.5	2	No odor		-	Raw water > 2.25 mg/L per Hach field test
40	11/1	10:50	9.7	28.7	6.04	31.6	31.3	21	9	2	Slight odor		-	< 0.25 mg/L per Hach field test
41	11/1	11:10	9.7	28.8	4.26	22.0	21.7	21	9	2	Slight odor		-	
42	11/1	11:30	9.7	28.7	2.29	13.8	13.4	21	10	2	H ₂ S Odor		-	
43	11/2	09:30	9.7	28.7	8.70	51.1	50.7	21	8.5	2	No odor		-	Raw Water > 2.25 mg/L per Hach field test
44	11/2	09:35	9.7	28.7	7.38	41.4	41.0	21	8.5	2	No odor		-	
45	11/2	09:40	9.7	28.6	6.70	36.4	36.0	21	9	0	No odor		-	
46	11/2	09:45	9.6	28.5	5.90	31.6	31.2	21	9	2	No odor		-	
47	11/2	09:47	9.6	28.5	5.41	28.7	28.3	21	9	2	Slight H ₂ S Odor		-	Negative Hach field test

Table 4 – Sample Login Table														
Run	Date	Time	Flow Rate gpm	O ₂ Flow slm	O ₃ Conc. Wt%	O ₃ Gen Power %	O ₃ Gen Power %	Reactor Inlet Pressure (Pi) psi	Reactor Outlet Pressure (Po) psi	Sand Filter Pressure (Ps) psi	Effluent H ₂ S Conc. mg/L	Residual O _{3 m} mg/L	H ₂ O ₂ Conc. %	Notes
48	11/2	09:52	9.8	28.5	5.08	26.8	26.4	21	9	2	Slight H ₂ S odor		-	Negative Hach field test
49	11/2	09:56	9.7	28.4	4.70	24.8	24.4	21	9	0	Slight H ₂ S odor		-	Negative Hach field test
50	11/2	10:05	9.7	28.4	4.16	22.0	21.6	21	9	2	Slight H ₂ S odor		-	Negative Hach field test
51	11/2	10:10	9.7	28.3	3.16	17.6	17.4	21	9	2	Slight H ₂ S odor		-	Negative Hach field test
52	11/2	10:15	9.7	28.3	2.10	13.7	13.6	21	9	2	H ₂ S Odor		-	Negative Hach field test
53	11/3	11:20	9.6	28.9	1.18	10.0	9.9	21	9	2	H ₂ S Odor		-	SF >= 2.25mg/L H ₂ S; ~1.2 mg/L H ₂ S
54	11/3	11:40	9.6	28.8	3.36	17.6	17.4	21	9.5	2	Slight H ₂ S odor		-	Negative Hach field test
55	11/3	11:55	9.7	28.8	4.34	22.0	21.7	21	9.5	2.5	Slight H ₂ S odor		-	
56	11/3	12:15	9.6	28.8	11.26	80.2	79.8	21	9.5	2.5	No odor		-	
57	11/6	14:35	9.8	28.9	5.22	28.8	28.4	21	9.0	3.5	No odor	0.35	-	
58	11/6	15:05	9.6	28.8	4.94	26.8	26.4	21	9.0	3.5	No odor	0.3	-	
59	11/7	10:55	9.7	28.8	3.30	17.6	17.4	21	8.5	4	No odor	0	-	
60	11/7	11:00	9.7	28.8	3.70	19.2	19.1	21	9	4	No odor		-	
61	11/7	11:02	9.8	28.8	3.89	20.1	19.9	21	9	4	No odor		-	
62	11/7	11:07	9.7	28.8	4.08	21.0	20.8	21	9	3.5	No odor		-	
63	11/7	11:12	9.8	28.8	4.27	21.9	21.7	21	9	4	No odor		-	

Table 4 – Sample Login Table														
Run	Date	Time	Flow Rate gpm	O ₂ Flow slm	O ₃ Conc. Wt%	O ₃ Gen Power %	O ₃ Gen Power %	Reactor Inlet Pressure (Pi) psi	Reactor Outlet Pressure (Po) psi	Sand Filter Pressure (Ps) psi	Effluent H ₂ S Conc. mg/L	Residual O ₃ m mg/L	H ₂ O ₂ Conc. %	Notes
64	11/7	11:20	9.8	28.8	4.63	23.9	23.5	21	9.5	3.5	No odor	0.1 mg/L	-	
65	11/7	11:25	9.6	28.7	4.96	25.8	25.4	22	9	4	No odor	0.35 mg/L	-	
66	11/7	11:30	9.7	28.8	5.31	27.7	27.4	21	9.5	4	No odor		-	
67	11/7	11:35	9.8	28.8	5.46	28.7	28.3	21	9	4	No odor	>2.3 mg/L	-	
68	11/7	11:45	9.7	28.8	5.63	29.7	29.3	21	9	4	No odor		-	
69	11/8	09:30	9.9	27.3	4.84	24.8	24.4	22	9	5	H ₂ S Odor	1.8 – 2.3 mg/L	-	
70	11/8	09:45	10.0	28.6	4.23	22.0	21.7	21	9	5	H ₂ S Odor	1.2; >2.3; 0.35 mg/L	-	
71	11/8	10:05	9.9	28.7	3.75	20.1	19.9	21	9	5	No odor	0.0 – 0.1 mg/L	-	
72	11/9	10:40	9.7	28.7	5.40	27.7	27.4	22	11	5	No odor	>2.3 mg/L	-	
73	11/9	10:45	9.8	28.7	5.07	25.8	24.4	22	10	5	No odor	>2.3 mg/L	-	
74	11/9	10:47	9.7	28.8	4.87	24.8	24.5	22	10	5	No odor	>2.3 mg/L	-	
75	11/9	10:52	9.8	28.8	4.53	23.8	23.5	22	11	5	No odor	2.3 mg/L	-	
76	11/9	11:00	9.6	28.7	4.53	22.9	22.5	22	11	5	Slight odor	0.3 mg/L	-	
77	11/9	11:10	9.7	28.8	4.36	21.9	21.6	22	10	5	Light odor	0 – 0.1 mg/L	-	
78	11/9	11:15	9.8	28.7	4.18	21.0	20.7	23	10	5.5	Light odor	0	-	
79	11/9	11:20	9.7	28.8	3.99	20.1	19.9	23	10	5	Light odor	0	-	

Table 4 – Sample Login Table														
Run	Date	Time	Flow Rate gpm	O ₂ Flow slm	O ₃ Conc. Wt%	O ₃ Gen Power %	O ₃ Gen Power %	Reactor Inlet Pressure (Pi) psi	Reactor Outlet Pressure (Po) psi	Sand Filter Pressure (Ps) psi	Effluent H ₂ S Conc. mg/L	Residual O ₃ m mg/L	H ₂ O ₂ Conc. %	Notes
80	11/9	11:25	9.8	28.7	3.80	19.2	19.0	23	11	5	H2S Odor	0	-	
81	11/9	11:30	9.8	28.6	3.40	17.5	17.4	23	11	0	H2S Odor	0	-	
82	11/10	10:50	10.0	28.7	6.70	35.5	35.1	19	7	5.5	H2S Odor	~0.2 mg/L	-	No bubbling, frothing, spitting when effluent sample collected
83	11/10	11:15	10.0	28.7	8.80	51.1	51.1	19	6.6	5.5	No odor	~0.8 mg/L	-	No bubbling, frothing, spitting when effluent sample collected
84	11/10	11:30	10.0	28.7	9.90	60.8	60.8	20	7	5.5	No odor	~2.0 mg/L	-	No bubbling, frothing, spitting when effluent sample collected
85	11/13	12:48	9.6	28.7	4.78	24.8	24.5	25	11	6.0	H2S Odor	0.0 mg/L	-	
86	11/13	13:11	9.6	28.7	5.58	29.7	29.3	25	11	6.0	No odor	0.2 mg/L	-	
87	11/13	13:34	9.6	28.7	7.53	41.4	41.0	25	11	6.0	O ₃ odor	> 0.2 mg/L	-	Run Time: 59.3 hours; Recycle Time: 5.9 hours
88	11/14	09:50	10.3	28.8	5.55	28.7	28.3	17	4	3.0	H2S Odor	0.15 mg/L	-	No bubbling, frothing, spitting when effluent sample collected
89	11/14	10:05	10.3	28.6	6.29	33.5	33.2	17	4	3.0	H2S Odor	0.3 mg/L	-	No bubbling, frothing, spitting when effluent sample collected
90	11/14	10:25	10.2	28.7	8.10	46.3	45.9	17	4	3.0	No odor	>1.4 mg/L	-	No bubbling, frothing, spitting when effluent sample collected
91	11/14	11:30	10.4	28.7	8.11	46.2	45.8	17	4	3.0	No odor		4 mL/min	No bubbling, frothing, spitting when effluent sample collected
92	11/14	11:35	10.3	28.7	6.29	33.5	33.2	17	4	3.0	No odor		3 mL/min	No bubbling, frothing, spitting when effluent sample collected
93	11/14	11:50	10.4	28.8	5.50	28.7	28.3	17	4	3.0	H2S Odor		2.8 mL/min	No bubbling, frothing, spitting when effluent sample collected
94	11/15	11:17	10.2	28.6	5.62	28.7	28.3	20	8	3.5	No odor		2.8 mL/min	No bubbling, frothing, spitting when effluent sample collected
95	11/15	12:06	9.8	28.5	4.39	21.9	21.6	20	8	3.5	H2S Odor		2.2 mL/min	No bubbling, frothing, spitting when effluent sample collected

Table 4 – Sample Login Table														
Run	Date	Time	Flow Rate gpm	O ₂ Flow slm	O ₃ Conc. Wt%	O ₃ Gen Power %	O ₃ Gen Power %	Reactor Inlet Pressure (Pi) psi	Reactor Outlet Pressure (Po) psi	Sand Filter Pressure (Ps) psi	Effluent H ₂ S Conc. mg/L	Residual O _{3 m} mg/L	H ₂ O ₂ Conc. %	Notes
96	11/15	12:25	9.9	28.5	6.89	36.4	36	20	8	3.5	No odor		3.3 L/min	No bubbling, frothing, spitting when effluent sample collected
97	11/15	12:53	9.8	28.8	7.58	41.4	41.0	20	8	3.0			3.7 mL/min	No bubbling, frothing, spitting when effluent sample collected
98	11/15	13:17	9.6	28.7	9.84	60.8	60.4	20	8	3.0			4.8 mL/min	No bubbling, frothing, spitting when effluent sample collected

Notes: O₂ – Oxygen
O₃ – Ozone
Wt% - Weight percent
psi – Pounds per square inch
H₂S- Hydrogen sulfide
SLM – Standard Liters per Minute.

8 SYSTEM PHOTOS



Photo 1 – Barge and 700-gallon pillow tank used for collection of Salton Sea water and transfer to Baker Tank.



Photo 2 – Baker tank used to store Salton Sea water sample and to mix sodium sulfide (tank shown during installation).



Photo 3 – Feed pump with a variable frequency drive (forefront) and sand filter and final discharge tank (background), prior to installation.



Photo 4 – Advanced Oxidation Unit for ozone and ozone/peroxide.



Photo 5 – Bag filtration unit for backwash water prior to installation.



Photo 6 – Treatment system assembled.



Photo 7 – Power generator was used to power the advanced oxidation system and the VFD feed pump.



Photo 8 – Hach tests for dissolved sulfide and residual ozone were used in the field to select operation parameters.